



# Advances in Cloud Satellite Remote Sensing for ARM



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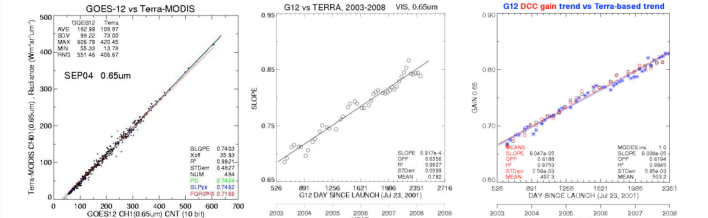
<http://www-angler.larc.nasa.gov/satimage/products.html>

## Introduction

Improvements in the characterization of 3-D cloud and radiation fields from satellite observations over large domains has been an ongoing effort within the ARM program for many years. Various algorithm adjustments and new techniques have been developed during the past 5 years through comparisons with ARM site data as well as other field program and satellite data. Some of the changes have already been incorporated into the NASA Langley satellite data products developed for ARM while many others will be incorporated during 2008. Those changes and the available products are discussed below.

## Improved Calibrations

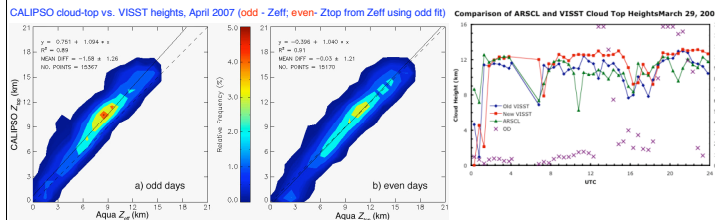
Long term intercalibrations between geostationary satellite imagers and MODIS on Terra & Aqua are providing the best calibrations available for deriving cloud microphysical properties. Trends confirmed using deep convective cloud (DCC) albedos. Improved calibrations are applied, when available, to new ARM satellite data & used to reprocess older data.



Improved narrowband-broadband conversions are being used to determine more accurate TOA fluxes (see Khaiyer poster).

## Improved Cloud-Top Heights

Cloud top heights from GOES are generally good for low clouds, but the physical top heights are often biased low for high clouds. A new parameterization has been developed from matched CALIPSO & MODIS VISST data for estimating the true cloud top altitude from the effective radiating height for optically thick ice clouds (Yost et al., 2008). New parameterization will give improved upper boundaries of thick clouds. New, steeper lapse rate to be used for low clouds.

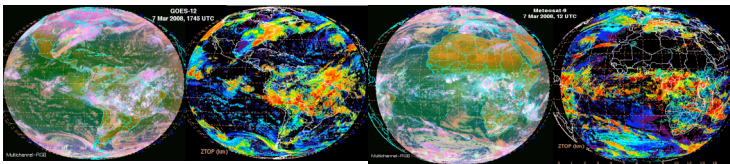


## Retrieval Model Changes

Thin cirrus cloud heights are often underestimated from GOES during the daytime but not at night (Smith et al., 2008), presumably as a result of using an asymmetry factor that is greater than those observed from in situ data. New phase functions based on roughened crystals will be used to derive smaller cloud optical depths & greater cirrus heights from GOES data. These results will be reinforced with CO2-slicing retrievals. Optical depth range has been increased from 128 to 512, with subsequent increases in LWP & IWP.

## New Domains

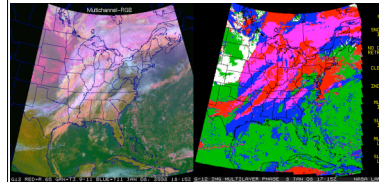
AMF domains (e.g., MASRAD, COPS, China) are being processed/reprocessed. Near-real time, 3-hr full disk retrievals for geostationary satellites. Global results available by summer, higher time/space resolution later/



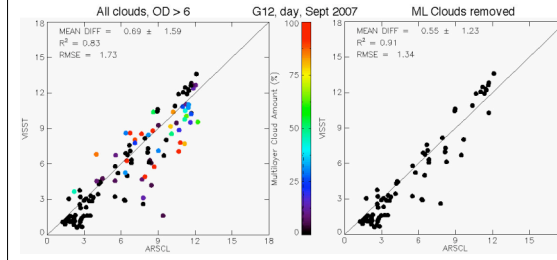
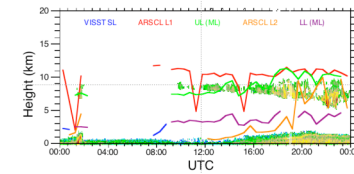
## Multilayered clouds over the SGP & eastern CONUS

Recent advances in multilayered cloud detection and retrieval using 10.8 and 13.3  $\mu\text{m}$  channels (Chang et al., 2008) are being incorporated into the real time retrievals for GOES-12 and Meteosat-8/9. These new techniques will provide better 3-D characterization of large-area cloud fields by providing upper (UL) and lower layer (LL) properties instead of just single-layer (SL) properties from the VISST.

GOES-12, 8 Jan 2008, 1715 UTC



Comparison of ARSCL and VISST Derived Cloud Top Heights (March 28, 2007)

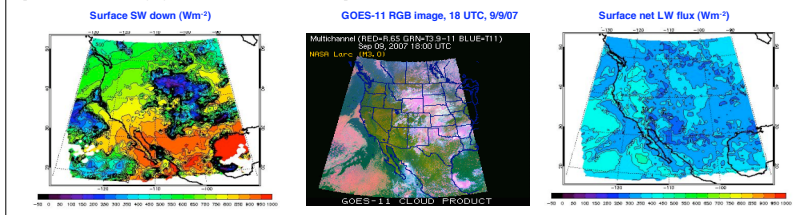


Verification of ML cloud detection

If scenes containing ML clouds (left), as determined with CO2 technique, are removed from comparison with ARSCL cloud top heights (right), both scatter and bias decrease. Here, the remaining bias is result of overestimate of low cloud height. New lapse rate will reduce that bias significantly.

## Surface Radiation Budget

Techniques used for determining the surface radiation budget from TOA broadband fluxes and clouds have been adapted for application to the ARM satellite cloud and radiation products. Preliminary analyses are being performed for 0.5° regions. Product will become operational after testing against ARM & BSRN sites completed.



## Summary

- Variety of new algorithms have been developed and tested using ARM and other datasets to improve the characterization of the large scale cloud and radiation fields that only satellite data can provide
- New techniques/domains are being introduced into operational ARM satellite analyses during 2008
- Validation will continue at other sites (NSA, TWP, & AMF)
- Improved method development will continue & changes implemented as they are proven

## Acknowledgments

This research supported by the ARM Program via ITF No. 18971 with NASA LaRC through Batelle, PNNL.